(54) COMMON CONTROL TELE-
COMMUNICATION SWITCHING
SYSTEM

(57) In a processor-controlled tele-
communications exchange, to avoid
overloading the computer the number
of call attempts per unit time is
checked at clock intervals and limited.
A prediction unit assesses from the
call distribution and the mix of call
types the expected computer
occupancy and on the basis of those
predictions fixes the number of call
attempts to be accepted.

Fig. 1.

Fig. 1.

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Fig. 2.

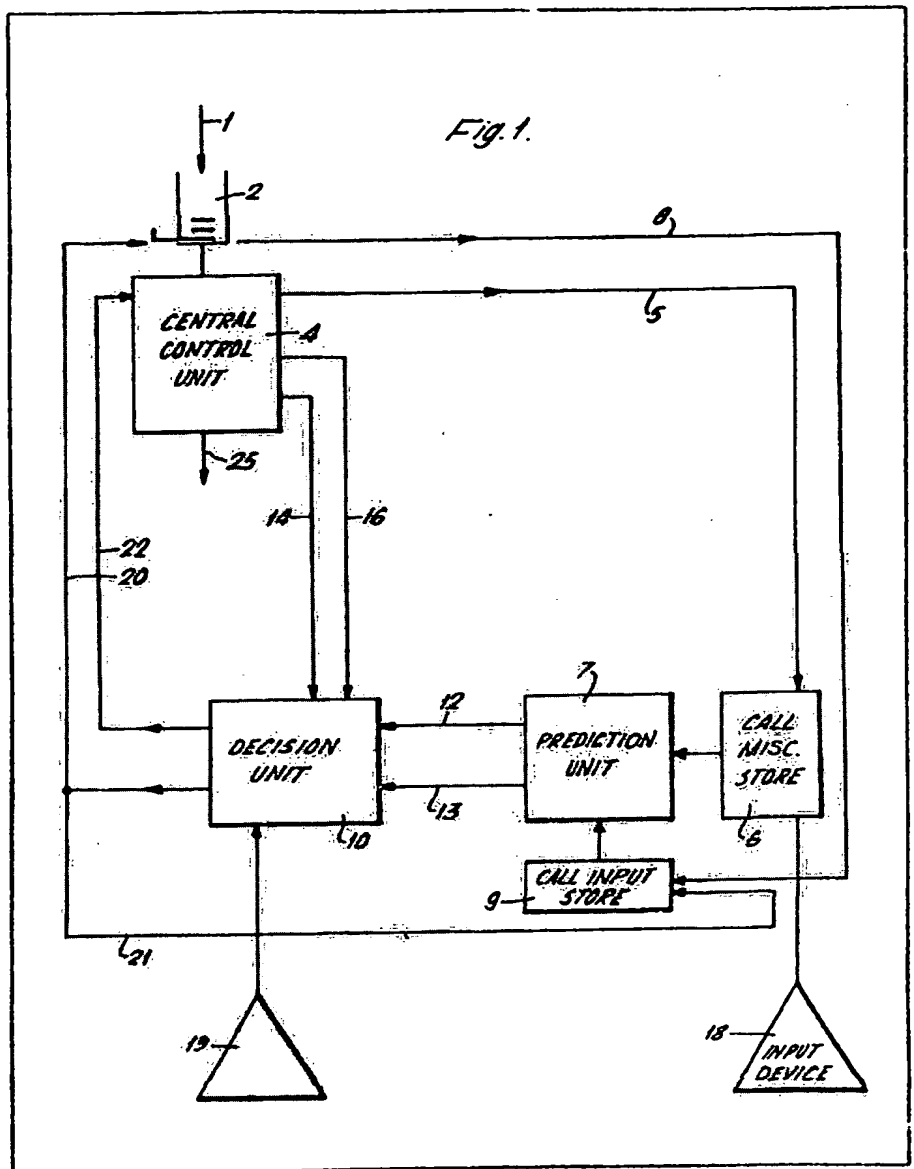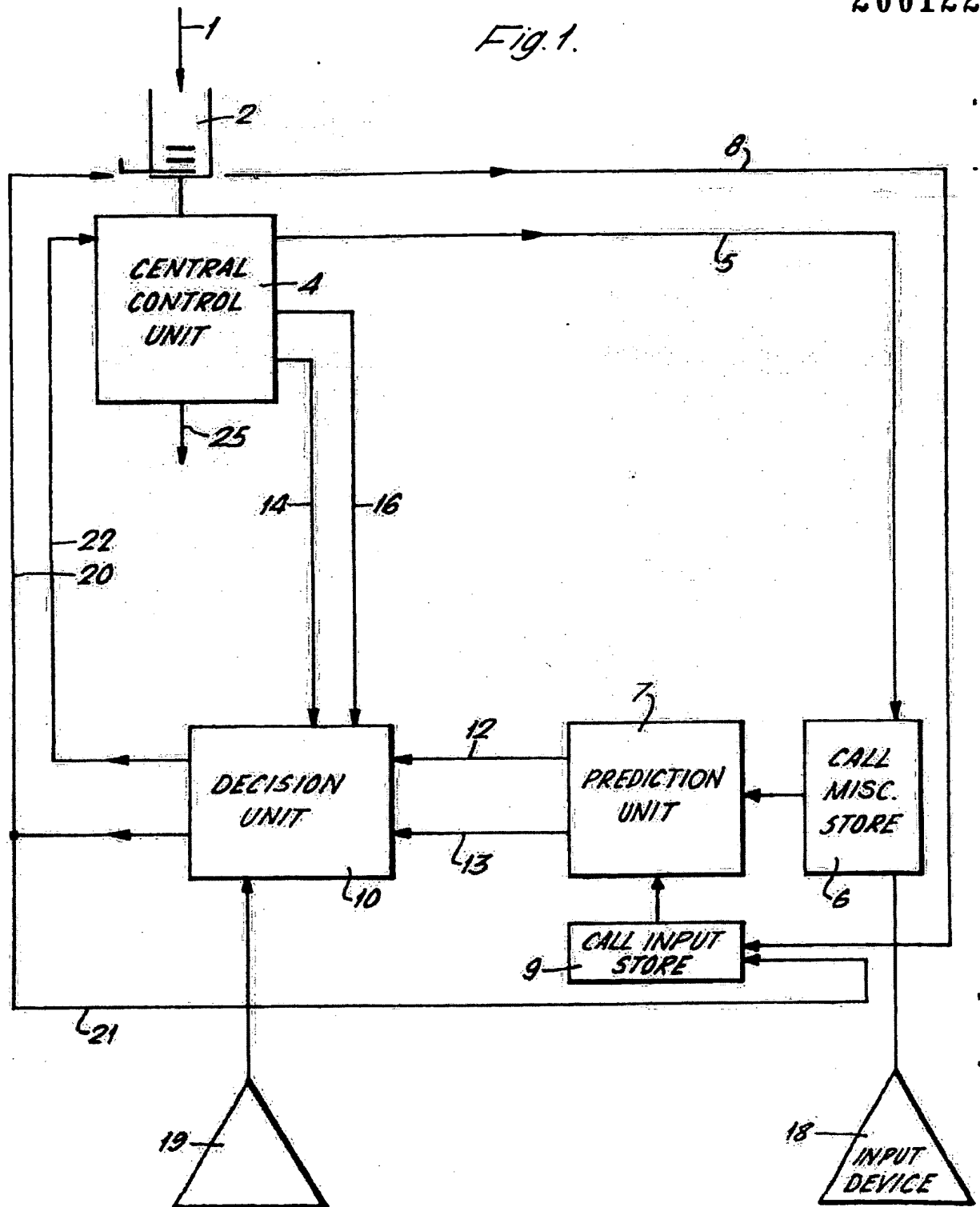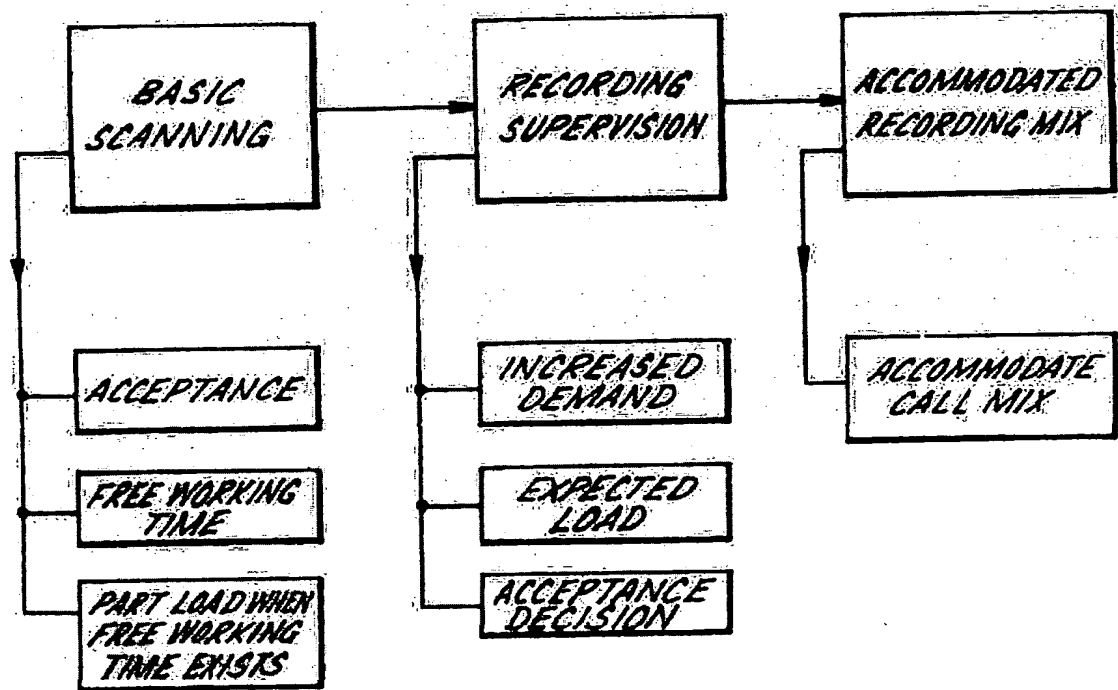| BASIC SCANNING		RECORDING SUPERVISION		ACCOMMODATED RECORDING MIX
ACCEPTANCE		INCREASED DEMAND		ACCOMMODATE CALL MIX
FREE WORKING TIME		EXPECTED LOAD		
PART LOAD WHEN FREE WORKING TIME EXISTS		ACCEPTANCE DECISION		

SPECIFICATION

COMMON CONTROL TELECOMMUNI-
CATION SWITCHING SYSTEM

This invention relates to a common control tele-
5 communication switching system comprising a
control unit and a decision unit which auto-
matically limits that part of the incoming call
attempts accepted for switching and, to avoid
overloading of the central control unit, checks, at
10 clock intervals, the number of call attempts
accepted per unit time, and limits this number.
Such common control electronic telecommuni-
cation switching systems can only handle a given
number of call attempts per unit time. To enable a
15 computer forming the control unit to establish a
requested connection, a sequence of control
instructions must be executed at given times.
During the execution of the individual instruction,
maximum permissible waiting times must not be
20 exceeded. If the system accepts too many call
attempts, a lack of storage locations or a trans-
gression of the maximum permissible waiting times
causes a break in the sequence of control
instructions or a mistreatment of a sequence. All
25 work performed by the central control unit for
such an unsuccessful switching operation is in
vain, and the control unit was occupied needlessly.
Thus it is necessary for the number of call attempts
accepted per unit time be limited. The
30 stochastically distributed incoming call attempts
must be constantly supervised, since it is not only
under overload conditions, but also in case of a
normal load being placed on the switching system,
that too many call attempts may arrive on a purely
35 random basis and for short periods of time.
The central control unit can be protected from
overload by limiting the number of call attempts
accepted in a fixed time interval — e.g. in one
second — to a fixed number which can be handled
40 by the control unit with a high probability. Since,
however, system occupancy is dependent not only
on the number of call attempts accepted for
switching but also on the type, composition, and
time distribution of the call attempts, sufficient
45 overload protection can only be ensured if a low
average occupancy of the control unit is provided
for.
In a known stored-programme-controlled tele-
communication switching system (U.S. Patent
50 3,623,007), the instantenous occupancy of the
control unit is measured, and the number of call
attempts accepted in a control interval is
controlled dependent on the measured occupancy.
The additional problems associated with the
55 stability and hysteresis of a closed loop are
alleviated by permitting the variation in the
number of accepted call attempts in the control
interval to take place only slowly and in small
steps. Despite this occupancy-dependent control,
60 however, an overload of the central control unit
cannot be prevented with certainty since the
delayed occupancy due to the already accepted
call attempts is not regulated, and thus may also

occur in a stochastic accummulation. On the other
65 hand, it is also possible for a relatively high
instantaneous occupancy of the control unit to
cause a reduction in the number of accepted call
attempts which then causes a very low occupancy
of the control unit. In the known switching system,
70 with large control intervals, traffic peaks are
sometimes not sufficiently worked off, or, with
small control intervals, waiting times may be
longer than necessary.
An object of the invention is to provide a tele-
75 communication switching system of the above-
mentioned kind in which overloading of the
central control unit is avoided, and in which
occupancy during heavy traffic is constantly held
in the range of the upper performance limit.
80 According to the invention there is provided a
common-control telecommunication switching
system including a control unit and a decision unit
which automatically limits the number of incoming
call attempts accepted for switching and to avoid
85 overloading the central unit checks, at preset
intervals, the number of call attempts accepted per
unit time and limits this number, wherein
associated with the decision unit there is a
prediction unit which receives information as to
90 the number of accepted call requests and which
determines the currently-expected occupancy of
the central control unit to be expected in a
subsequent control interval with the aid of the
received information and communicates such
95 occupancies to the decision unit.
The principal advantages of the invention are
that predictable overloads of the central control
unit are avoided, that the occupancy of the control
unit is levelled, and that the control unit can be
100 constantly operated error-free at its upper load
limit. In addition, the amount of control, computer
and storage equipment required is small.
An embodiment of the invention will now be
explained with reference to the accompanying
105 drawings, in which Fig. 1 is a block diagram
showing a common control telecommunication
switching system embodying the invention, and
Fig. 2 is a block diagram of the sampling control of
the system of Fig. 1.
110 In Fig. 1, subscriber lines indicated at 1 are
scanned successively at very short time intervals
by means of a waiting facility 2 to determine
whether there are any call attempts. This scanning
process and all other tasks to be performed by the
115 switching system are controlled by a central
control unit 4. These tasks include, besides the
"acceptance", i.e., the fixing of the number of call
attempts to be accepted for switching per unit
time, the call phases: pre-selection, dialling and
120 signalling, through-connection, answer, and
release. The central control unit performs these
sequences of tasks, which are necessary to
establish and release the desired connections, and
the task sequences necessary to optimize the
125 occupancy of the switching system, with the aid of
fixed operational programmes, taking into account
predetermined priorities.
In the above-mentioned call phases, information

on the measured partial occupancies is trans-
ferred from the central control unit 4 over a data
line 5 to a call mix store 6, and from there to a
prediction unit 7. Information on the number of
5 call attempts accepted per unit time is transferred
from the waiting facility 2 over a data line 8 to a
call input store 9, and from there to the prediction
unit 7.

The prediction unit 7 contains a memory
10 organized as a matrix, which is associated with a
decision unit 10, to which it supplies, over a data
line 12, information on the currently expected
occupancy of the central control unit 4, and, over
a data line 13, information on the control unit
15 occupancy to be expected in the subsequent
control interval. The lengths of the different
control and working intervals of the switching
system will be dealt with below.

The decision unit 10 is supplied from the central
20 control unit 4, over a data line 14, with measuring
information on the total occupancy of the central
control unit 4, and, over a data line 16, with
measuring information on critical delays in the
sequence of tasks performed by the central control
25 unit.

Via an input device 18, a predetermined call
mix. i.e., a predetermined breakdown of the call
attempts according to origin, destination, and fate
(degree of completion) can be entered into the call
30 mix store 6. Analogously, a maximum permissible
occupancy of the control unit 4 can be entered
into the decision unit 10 via a second input device
19.

The unit 10 generates, in a manner to be
35 described below, instruction signals which are
transferred over a data line 20 to the waiting
facility 2, where they determine the number of call
attempts accepted for switching. Over a further
data line 21, the output signals of the unit 10
40 control the occupancy of the call input store 9.

Under overload conditions to be described
below, the decision unit 10 generates further
control signals which are transferred over a data
line 22 to the central control unit 4, where they
45 initiate corresponding emergency task sequences.

The accepted call attempts are transferred from
the waiting facility 2 over a connecting line 24 to
the central control unit 4. The passing-on of the
call attempts processed by the central control unit
50 4 is indicated by a connecting line 25.

The operation of the switching system will now
be explained in greater detail.

The individual, successively occurring
occupancy phases, due to the establishment and
55 the release of a connection, begin with the
preselection and end with the release, and result in
the total occupancy of the central control unit,
which is dependent on the input or request
process.

60 The scanning of the condition of the subscriber
lines, i.e., the determination of the incoming call
attempts, causes a normal load to be placed on the
central control unit 4 which is independent of the
input process. By counting the requests for the
65 individual task sequences — e.g. for preselection,

dialling, etc. — the partial occupancies of the
control unit by the different task sequences are
constantly determined. These partial occupancies
depend on the composition of the call attempts.
70 The information about the partial occupancies is
communicated to the call mix store 6 every K.M.τ
sec, where τ is the basic clock interval at which the
scanning of the call attempts and the essential task
sequences of the central control unit are carried
75 out, and K and M are fixed integral factors for the
clock periods of less frequently performed task
sequences. The information in the store 6
determines in this store the call mix parameters. If
no measured data are present, or other parameters
80 are to be used, a standard call mix is entered into
the store 9 via the input device 18. The call input
store 9 also associated with the prediction unit 7, is
fed from the decision unit 10 only with the input
process information necessary to predetermine the
85 expected occupancies of the central control unit 4.

The unit 4 constantly determines the share of
free processing time and the number of waiting
periods of a given critical task sequence of low-
level priority, and sends corresponding
90 information to the unit 10. An undue delay in the
individual task sequences in the unit 4 could result
in a misinterpretation of call numbers, and this
must be avoided. When the number of waiting
periods exceeds a predetermined maximum
95 permissible number, the decision unit 10 gives an
instruction which initiates in the central control
unit 4 an emergency task sequence which reduces
the normal load presented to the unit 4, the
scanning process being interrupted for a given
100 time, and independent task sequences of no
urgency being broken off.

During normal operation, the unit 10 —
dependent on the communicated predetermined
maximum occupancy which can be expected if the
105 input process is not subjected to any major
changes — determines the number of call attempts
to be accepted in a control interval. This ensures
than an increased stock of requests as would result
from the number of call attempts to be accepted is
110 not likely to lead to an overload of the central
control unit at a later time.

For stability reasons, the call mix parameters are
adapted to the varying partial occupancies of the
central control unit 4 relatively slowly. In addition,
115 a sudden change in the type and composition of
the call attempts may cause an unforeseen
increase in the occupancy of the control unit 4. To
prevent such an overload, if the instantaneous
occupancy, determined via the free processing
120 time of the central control unit, exceeds the
expected occupancy by at least ten per cent in
more than two successive control intervals, the
number of accepted call attempts is reduced by
twenty per cent as a precaution. If, however, the
125 actual occupancy exceeds the permissible
occupancy limit, an emergency task sequence is
initiated for a few control intervals which stops the
acceptance of call attempts and reduces the
normal load placed on the unit 4.
130 The prediction matrix contained in the unit 7

takes into account the specific features of the switching system and consists of the following storage locations:

5
P_0, P_1, P_2
$D_0, D_1, D_2, \ldots D_{35}$
$S_0, S_1, S_2, \ldots S_{46}$
$A_0, R_0, O,$

where the symbols P denotes the task sequence "preselection", D "dialling, signalling", S
10 "through-connection", A "answer", R "release", and O the "normal load". The subscripts designate the consecutive, systematic transfer of the contents of the individual storage locations, the number of the storage locations for the different
15 task sequences corresponding to the given and expected time delays, counted from the preselection, and to the duration of the occupancy for this task sequence.

The parameters of the call mix are assigned the
20 following storage locations which, for simplicity, are designated by the following capital letters in accordance with the task sequence:

P, D, S, A, R.

These parameters are a measure of the expected
25 task densities in the unit μs processing time per call attempt and per interval τ.

The contents of the call input store 9 are adapted to the input process. The transfer is effected every $K \cdot \tau$ sec by the transfer procedure
30 given below, where L is the number of call attempts accepted in the last control interval. The equations should be read as follows: $P_0=P_1+L$, for example, means: "Take contents of storage location P_1, add the number L, and store the result
35 in storage location P_0".

$P_0=P_1+L$
$P_1=0,5 \cdot L$
$P_2=0,99\ P_2+0,01 \cdot L$
$D_0=D_1$
40 $D_1=D_2$
$D_2=D_3+L$
$D_3=D_4+L$
.
.
$D_{34}=D_{35}+L$
45 $D_{35}=L$

$S_0=S_1$
$S_1=S_2$
.
.
$S_{34}=S_{35}$
50 $S_{35}=S_{36}+0.1\ L$
$S_{36}=S_{37}+0.3\ L$
$S_{37}=S_{38}+0.5\ L$
$S_{38}=S_{39}+0.8\ L$
$S_{39}=S_{40}+L$
55 $S_{40}=S_{41}+L$
$S_{41}=S_{42}+L$
$S_{42}=S_{43}+0.8\ L$
$S_{43}=S_{44}+0.5\ L$
$S_{44}=S_{45}+0.3\ L$
60 $S_{45}=0.1\ L$

$A_0=0.99 \cdot A_0+0.08 \cdot L$
$R_0=0.99875 R_0+0.0175 \cdot L$

As mentioned, the call mix parameters are transferred only slowly (i.e., every $K \cdot M \cdot \tau$ sec, the
65 parameters are changed by a maximum of 20%) as follows:

$P=0.8P+0.2P'$	Initial values:	$P=16$
$D=0.8D+0.2D'$	input of the	$D=1.5$
$S=0.8S+0.2S'$	standard call	$S=8$
70	$A=0.8A+0.2A'$	mix	$A=8$
$R=0.8R+0.2R'$		$R=14$

where the primed letters represent the new values determined via the measured partial occupancies of the central control unit.
75 The prediction matrix of the unit 7 contains a simulation configuration of the occupancy of the unit 4, and this simulation configuration determines the occupancy of the control unit.

The occupancy expected at a particular
80 instant is determined by working off the orders on hand:

$$C_0=(0+P \cdot P_1+D \cdot D_0+S \cdot S_0+A \cdot A_0+R \cdot R_0)K_0$$

where K_0 is a normalization constant (e.g. $1/1000$ sec/μ sec), so that C_0 represents a dimensionless
85 occupancy share.

A mean call intensity is determined every τ seconds by the following transfer:

$$L_0=0.95 \cdot L_0+0.05L$$

The occupancy D_{Ei} for "dialling" is
90 predetermined for the i-th future interval as follows ($i \leq 32$):

$$D_{Ei}=D_i+(i-2)L_0, i>1$$

Let the upper occupancy limit be B. The first limitation of the number of accepted call attempts
95 is determined by the "preselection":

$$L_p = \frac{1}{P}\ (B-C_0)$$

To prevent the task sequences "dialling", "signalling" and "through-connection" from causing too high an occupancy of the central
100 control unit 4, the following values are fixed:

$$S_M=\max\{S_{41}+3.7L_0, S_{40}+2.7L_0, S_{30}+1.7L_0\}$$

$$D_M=\max\{D \cdot D_3+S \cdot S_3, D \cdot D_{E4} + S \cdot S_4, D \cdot D_{25}+S \cdot S_5\}$$

$$L_s=\frac{1}{S} \cdot [B-(0+D \cdot 34L_0+P \cdot 1.5L_0+A \cdot A_0+R \cdot R_0)]-S_M$$

$$L_D = \frac{1}{D} \cdot [B-(0+D_M+P \cdot 1.5L_0+A \cdot A_0+R \cdot R_0)]$$

The smallest of the values of L_p, L_D and L_s so formed represents an indication of subsequent processing bottlenecks which can, in all probability, be avoided if the decision unit 10 is
5 designed so that the number of call attempts to be accepted in the control interval having started — unless an emergency task sequence is initiated — satisfies the equation

$$L' = Min\ (L_p,\ L_D,\ L_s).$$

10 The emergency task sequences are initiated as follows: let us assume that a free processing time share F has been measured for the central control unit 4. If

$$\frac{1-F-C_0}{1-F} > 0.1,$$

15 In more than two successive control intervals, operation with a number of accepted call attempts reduced by 20% will be initiated as a precaution,

$$L' = 0.8 \cdot L',$$

and currently unnecessary operations of the
20 central control unit 4 will be deferred. If the afore-mentioned critical task sequence is delayed by more than 3·τ sec, an instruction from the decision unit 10 will initiate a break in the acceptance of call attempts for at least three control intervals and
25 interrupt the scanning process. The emergency task sequence will be discontinued after three control intervals at the earliest when 1—F<B, i.e., when the occupancy of the central control unit 4 has fallen below the maximum permissible limit.
30 The length of the control interval and that of the call mix adaptation interval are determined by the capacity of the central control unit 4. They must be chosen so that not more than about 1% of the processing time of the central control unit is
35 expended on the control function in the state of high occupancy. Thus, the lengths of these intervals are fixed as follows: K=10 ... 20 and M=10 ... 20.
 Fig. 2 is a block diagram of the sampling control
40 of the telecommunication switching system according to the invention. It shows the sampling and scanning sequences, which have different cycle times.
 After every basic sampling interval of, e.g., 15 to
45 25 ms, the subscriber lines are scanned for the presence of call attempts, the free processing time of the central control unit is determined, and, if there is free processing time, the partial occupancies of the central control unit are
50 determined by the individual switching sequences.
 After K-times the basic sampling interval, the occupancy of the central control unit 4 is supervised, the number of call attempts to be accepted is fixed, and the expected occupancy is
55 determined.
 Every K·M·τ (τ=15 to 25 ms), the parameters characterizing the call mix are adapted.

 The devices controlling the telecommunication switching system according to the invention are
60 described in the foregoing as permanently wires circuits. They may also be implemented in the form of operational programmes permanently stored in the working memory of a central control unit 4 designed as a central processor.

65 CLAIMS
 1. A common-control telecommunication switching system including a control unit and a decision unit which automatically limits the
70 number of incoming call attempts accepted for switching and to avoid overloading the central unit checks, at preset intervals, the number of call attempts accepted per unit time and limits this number, wherein associated with the decision unit
75 there is a prediction unit which receives information as to the number of accepted call requests and which determines the currently-expected occupancy of the central control unit to be expected in a subsequent control interval with
80 the aid of the received information and communicates such occupancies to the decision unit.
 2. A common-control telecommunication switching system including a control unit and a
85 decision unit which automatically limits the number of incoming call attempts accepted for switching and to avoid overloading the central control unit checks, at clock intervals, the number of call attempts accepted per unit time and limits
90 this number, wherein the decision unit is assigned a prediction unit which receives information on the distribution of the number of accepted call attempts and on the call mix, and which determines the currently-expected occupancy of
95 the central control unit and the occupancy of the central control unit to be expected in a subsequent control interval with the aid of the received information, and communicates these occupancies to the decision unit.
100 3. A system as claimed in claim 1, wherein the prediction unit is assigned a call mix store which receives information on the partial occupancies of the central control unit due to individual switch-ing phases of the call attempts.
105 4. A system as claimed in claim 3, wherein the information to be received in the call mix store is data to be transferred from the central control unit.
 5. A system as claimed in claim 3, wherein the
110 information to be received in the call mix store is predetermined data.
 6. A system as claimed in claims 2, 3, 4 or 5, wherein the prediction unit is assigned a call input store which receives information on the call
115 attempts accepted for switching.
 7. A system as claimed in any one of claims 2 to 6, wherein the prediction unit contains computing devices which determine the occupancies of the central control unit.
120 8. A system as claimed in any one of claims 2 to 7, wherein the decision uinit contains comparing devices which compare the currently expected

occupancy of the central control unit with the
measured occupancy of this unit, and the
occupancy expected in the subsequent control
interval with a predetermined maximum
5 occupancy.

9. A system as claimed in claim 8, wherein the
decision unit contains computing devices which fix
the number of call attempts to be accepted in the
subsequent control interval on the basis of the
10 results of the comparisons and of the
predetermined maximum occupancy of the central
control unit.

10. A system as claimed in claim 9, wherein the
decision unit includes an extrapolation device
15 which determines the occupancy to be expected in
the subsequent control interval.

11. A system as claimed in any one of claims 2 to
10, wherein the decision unit includes a protective
device which reduces the normal work load placed
20 on the control unit as well as the number of call
attempts acceptable in the subsequent control
interval if the measured instantaneous occupancy
exceeds the expected occupancy in a
predetermined manner.

25 12. A system as claimed in any one of claims 2 to
11, wherein the decision unit includes an
emergency control which reduces the normal work
load placed on the control unit when a critical load
is exceeded.

30 13. A telecommunication switching system
substantially as described with reference to the
accompanying drawings.